A QUANTITIVE ECOLOGICAL INVESTIGATION OF THE KRANTZKLOOF FOREST, NATAL

E. J. MOLL

(Botanical Research Institute, Department of Agricultural Technical Services)

ABSTRACT

A brief account of the location, topography, geology and climate of the area and a short qualitative description of the forest are given. An enumeration of the various synusiae sampled and the different parameters employed is presented. Twenty-six combinations of data were ordinated using the Wisconsin technique, and a method first employed by Woods and Moll[3] was used to find the most efficient ordination. Performance of selected forest species is discussed with reference to environmental data collected at each sampling site.

INTRODUCTION

The area of forest analysed is in the Krantzkloof Nature Reserve about 20 km WNW of Durban at the intersection of co-ordinates 29° 46′ South and 30° 50′ East. The forest extends in a belt along the south-facing slopes of a steep-sided river valley; the altitude varies from 300—500 m.

PHYSIOGRAPHY

Topography

The forested area is divided into two sections by a line of cliffs some 40—70 m high. Above the cliffs the forest is shorter, with rather more *Protorhus longifolia* as a canopy tree, than the forest below, which has a greater predominance of *Drypetes gerrardii* in the canopy. The ground above and below the cliffs is steep; from 20°—30°.

Geology.

A thick layer of Table Mountain Sandstone (T.M.S.) overlies Basement Granite, with the contact-zone at the base of the cliffs.

Soils.

The soils above the cliffs are derived from T.M.S. and are shallow, sandy and well drained. The soils below the cliffs are also shallow, with numerous large areas covered by T.M.S. and Granite scree.

Climate

No climate data are available from the area, but temperatures are mild (mean annual of about 18°C) with little or no frost. Rainfall is about 1,000 mm per annum and mist occurs, although no measures of frequency or duration are available (personal communication with local residents).

GENERAL DESCRIPTION

The forest is at the upper limit of Acocks's[1] Coastal Forest and Thornveld veld type and can be briefly described as having four strata, these are:—

(i) A continuous canopy from 11—20 m high with *Protorhus longifolia*, *Drypetes gerrardii*, *Anastrabe integerrima* and *Combretum kraussii* the common species.

(ii) A discontinuous subcanopy layer from 4·5—11 m high. Common species are *Bequaertiodendron natalense*, *Tricalysia capensis*, *Eugenia natalitia*, *Cassipourea gerrardii*, *Ochna arborea* and *Cryptocarya woodii*.

(iii) A discontinuous layer of shrubs from 0·25—3 m high with *Encephalartos villosus*, *Dracaena hookeriana*, *Popowia caffra* and *Uvaria caffra* the most common species.

(iv) A discontinuous layer of herbaceous species with the most widespread being *Cyperus albostriatus* and *Oplismenus hirtellus*.

Unlike many other forests of Natal which have many lianes and/or ephiphytes, the forest at Krantzkloof has few.

SAMPLING PROCEDURE

Plot size and distribution

Each sample plot was 40 × 40 m in size and was subdivided into 16, subplots of 10 × 10 m. By adding contiguous sub-plots, plot sizes of 20 × 20, 20 × 40 and 40 × 40 m were obtained.

The choice of plot size was based on previous estimates of the density of canopy tree species; the size had to be large enough to include a small number of canopy trees, but not so large that the labour of counting shrubs became prohibitive.

A grid comprising 12 equal-sized squares, approximately two hectares in size, was placed over a greatly enlarged aerial photograph of the forest and one plot was located in each grid-square. Four grid-squares were in a line along the top of the cliffs and eight below. Plots were located by pacing a random distance from the corner of a grid-square, along the cliff top or base, then a further random distance at right angles to the cliff.

No criteria were used to determine the minimum numbers of plots required for effective sampling. The twelve 40 × 40 m plots, covering approximately 10% of the total area of forest, excluding marginal zones, were deemed sufficient.

Vegetation data

Only woody plants were sampled and these were arbitrarily subdivided into three synusiae:—

(i) Canopy; defined as all tree species with crowns exposed to full sunlight.

(ii) Intermediate: defined as all species above 2 m but not contributing to the canopy.

(iii) Shrub: defined as all species from 0·25—2 m high.

Vegetation parameters

Absolute density values per 10 × 10 m sub-plot were collected so that for each 40 × 40 m plot a value for absolute density and local frequency was available. Apart from species density four basic environmental factors were noted: the angle of slope, aspect, geology and an estimation (on a scale of four) of the visual quantity of surface boulders.

ORDINATION

The method of ordination developed by Bray and Curtis[2] was used to analyse the data collected. It is based on a floristic comparison of sampled data and assumes that the floristic composition of a site is an expression of the environment of that site.

The aim of the analysis was to ascertain the optimum plot size, parameter and synusia, or combination of synusiae, for analysing this forest type and to study facets of the ecology of some woody species.

Data ordinated

The various synusial and plot size combinations ordinated are shown in Table 1. Density values for all five synusial combinations were converted to percentage frequency based on the 10 × 10 m sub-plots. It was thus possible, using various synusial combinations, vegetation parameters and plot sizes, to obtain a total of 26 different ordinations.

When the same species occurred in more than one synusia the values were not summed but kept discrete in synusial combinations 'b' and 'c' (Table 1). Consider a hypothetical example of two plots each containing a common species 'Z'; present once in the canopy and 99 times in the shrub synusiae of one plot and 99 times in the canopy and once in the shrub synusiae of the other. It is not justified to equate the two plots on the bases of 'Z' being present 100 times in each. It is much more meaningful to keep the synusiae discrete and consider the same species, in different synusiae, as entities.

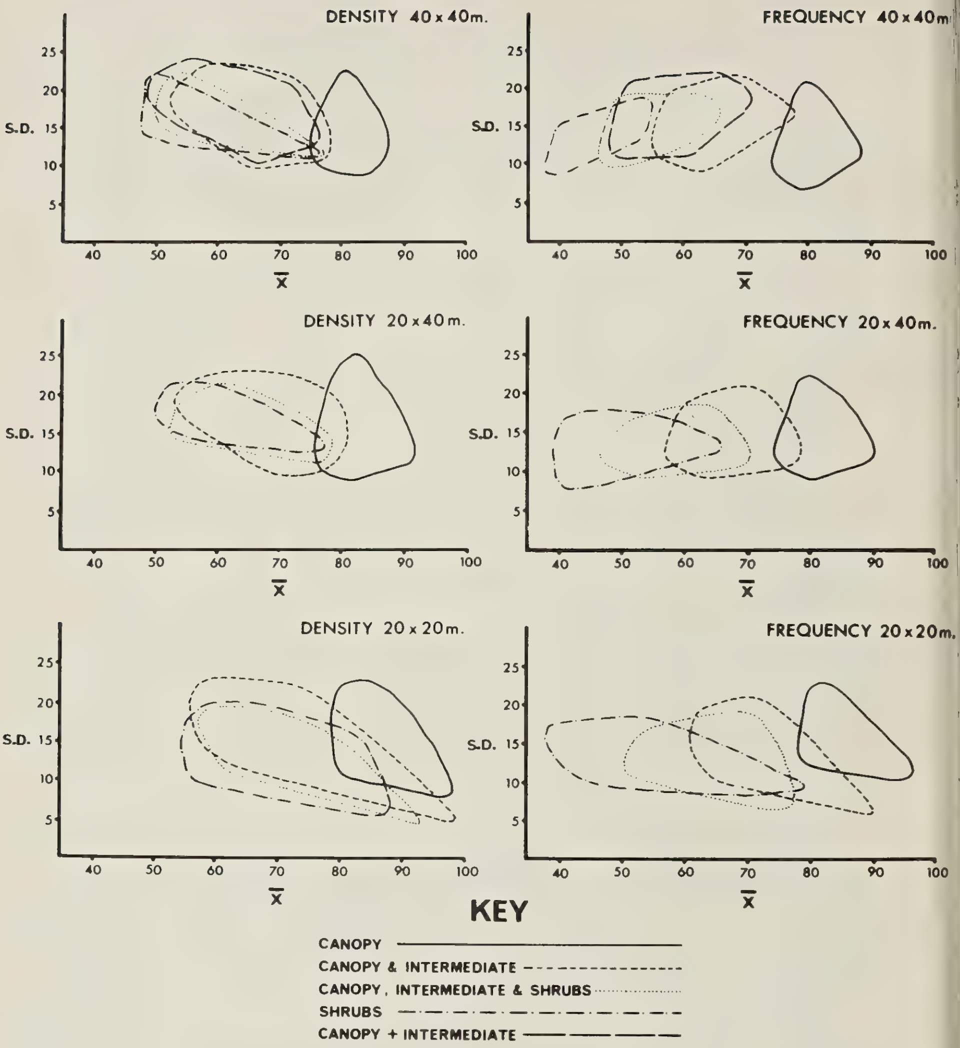

FIGURE 1.
Distribution of S.D. and $\bar{x}$ values of the three sizes of plot, two parameters and five combinations of synusiae plotted against each other.

Table I. The possible combination of synusial data and plot size.

Synusial Combinations	Plot Size		
	40 × 40 m	20 × 40 m	20 × 20 m
(*a*) Canopy	√	√	√
(*b*) Canopy intermediate	√	√	√
(*c*) Canopy, intermediate and shrubs	√	√	√
(*d*) Shrubs	√	√	√
(*e*) Canopy + intermediate	√		

Results and discussion.

As such a wide array of data is available from the possible 26 ordinations, some objective method of selecting the best ordination had to be employed. A technique developed by Woods and Moll[3] was used. The mean ($\bar{x}$) of the inverse of the indices of similarity[2] between every plot and every other, was plotted against the standard deviation (S.D.) of the mean (Fig. 1). Data with a high $\bar{x}$ and S.D. gave the two-dimensional ordination with best use of factor space. By plotting each combination of data it was possible to see which set was the best.

With reference to Fig. 1 the canopy density data for the 20 × 40 m plot size has the highest S.D. and a high $\bar{x}$, therefore makes best use of factor space.

As expected when considering broad ecological trends in forest the canopy is the most important synusia, for it is the dominant synusia upon which the entire forest structure and microclimate depend. Furthermore, since canopy species bear the full brunt of external climatic change they will exhibit a more accurate pattern in relation to the macro-environment. It may be argued that the fiist indicators of an environmental change are the herbaceous plants with a short life cycle, yet forests have taken hundreds or perhaps thousands of years to develop and if forest ecology is to be studied the short periods of climatic change, as long as they are not detrimental to the woody plants, are not important to the general forest ecology.

Comparison of plot size with density and frequency is interesting. The pattern exhibited is similar for each plot size; density is better than frequency showing little difference between the synusial combinations. However, with frequency there are marked differences, canopy is best followed by canopy and intermediate, shrubs, and lastly canopy, intermediate and shrubs. This is to be expected as frequency values greatly reduce the importance of dense local aggregations of species. A final observation, important for future studies, is that there is not a great deal of difference between canopy density and canopy frequency though the former is slightly better.

Two axes, X and Y, were sufficient to account for the floristic variability of the 20 × 40 m canopy density data and the resulting two dimensional scatter, shown in Fig. 2., has a significant correlation coefficient (between measured inter-plot distances and calculated dissimilarity values) of 0·71.

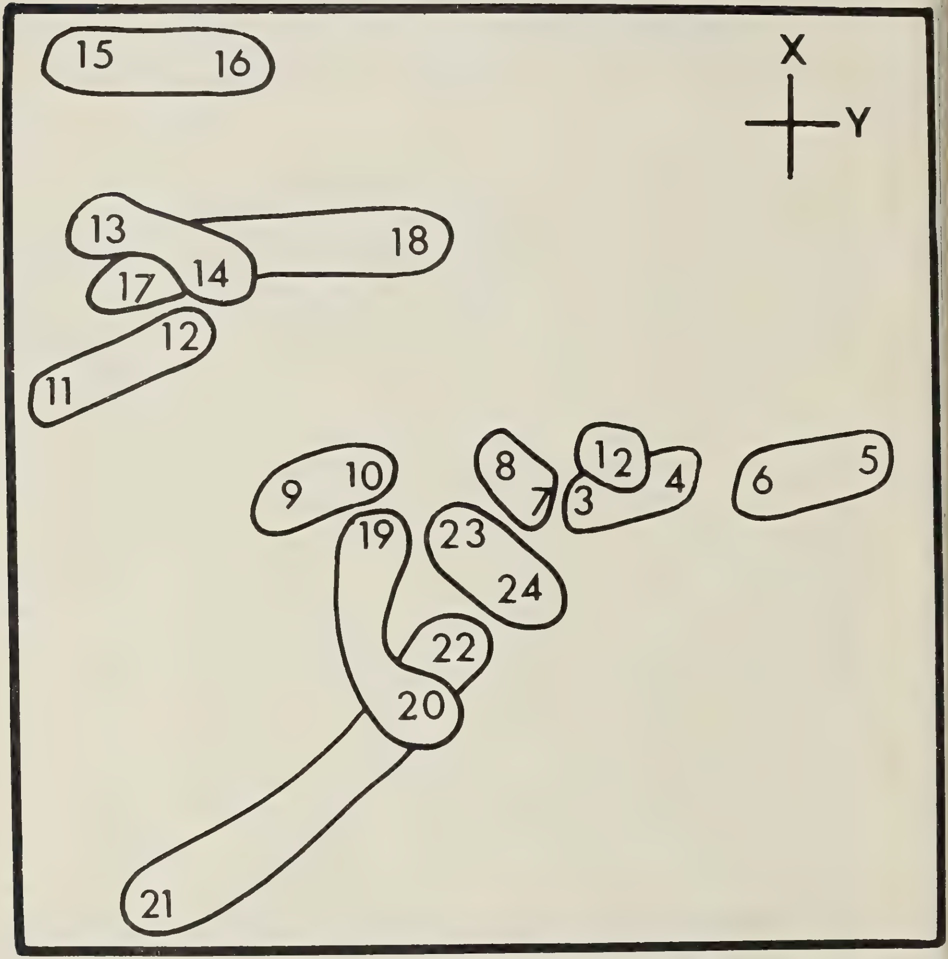

FIGURE 2.
Ordination of 20 × 40 m canopy density. Contiguous plots are ringed.

The 24 points, representing the 20 × 40 m plots, of the scatter diagram are derived from halving the twelve, 40 × 40 m plots. Contiguous plots have been ringed to give some indication of the homogeneity of the original, larger plot size.

Fig. 3 shows the collected environmental data plotted within the ordination and isolines are used to draw attention to high and/or low ratings in these and subsequent diagrams.

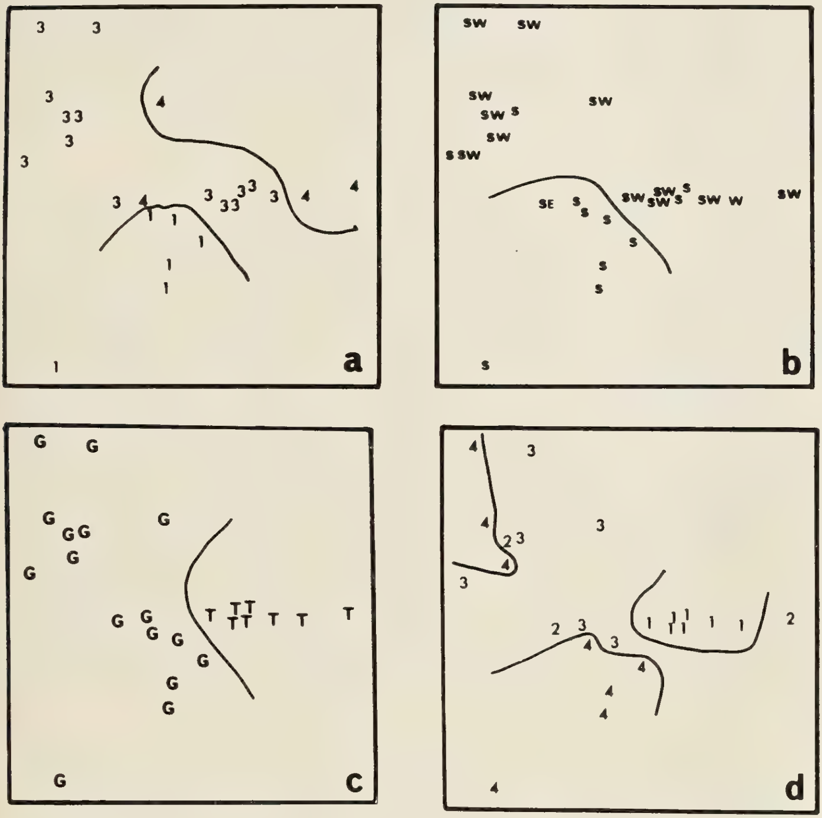

FIGURE 3.

Distribution within the ordination of: (*a*) angle of slope (1=14°—24°, 2=28°—34° and 3=>35°); (*b*) aspect (S=south, SE=southeast, SW=southwest and W=west); (*c*) geology (T=T.M.S. and G=granite); and (*d*) rocks (minimum to maximum on a scale 1–4).

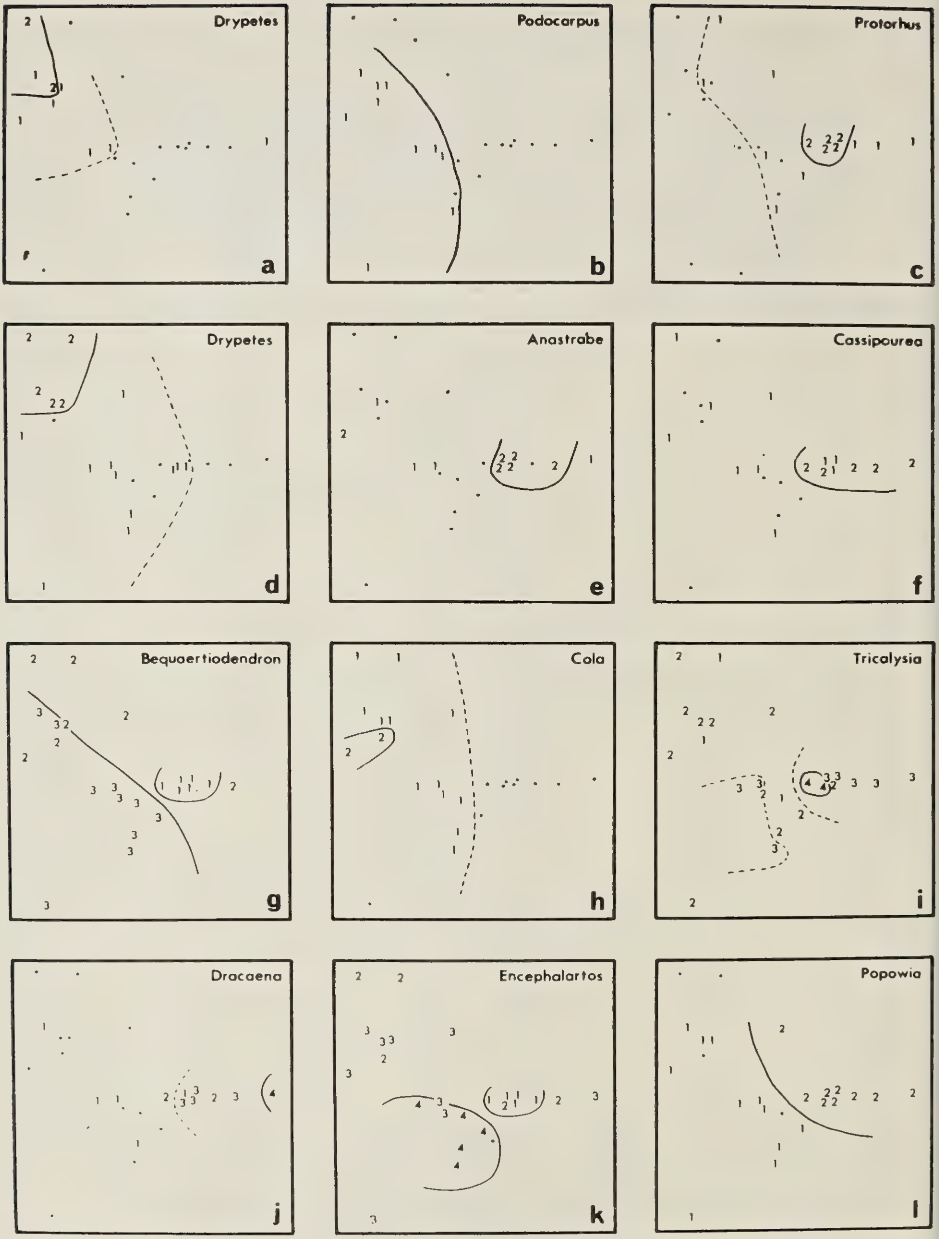
Drypetes
a
Podocarpus
b
Protorhus
c
Drypetes
d
Anastrabe
e
Cassipourea
f
Bequaertiodendron
g
Cola
h
Tricalysia
i
Dracaena
j
Encephalartos
k
Popowia
l

Fig. 4 shows the distribution of selected canopy, intermediate and shrub species within the ordination. The species selected occurred in ten or more plots and show relationships with the environmental factors in Fig. 3.

With reference to Figs. 3 and 4; *Drypetes* (Fig. 4*a* and *d*) occurs in the medium steep, southwest-facing plots on granite with much boulder scree, *Podocarpus* (Fig. 4*b*) is similar in performance to *Drypetes*, while *Protorhus* (Fig. 4*c*) occurs on the medium steep, south- to southwest-facing plots on T.M.S. with least boulder scree. Similar comparisons can be made with the other species plotted in Fig. 4.

Because of limited space additional species data and the suggested site-succession relationships from Figs. 3 and 4 have been summarized in Fig. 5.

Conclusions

The analysis of 26 different combinations of data, collected from 12 restrictedly randomized 40 × 40 m plots, by the Wisconsin[2] ordination procedure was investigated using the method developed by Woods and Moll[3]. Canopy density data for the 20 × 40 m plot size were found to give the best ordination. The various environmental and species density data were plotted within this ordination and the results are summarized in Fig. 5. The plots on T.M.S. above the cliffs were considered seral to those on granite below. Seral species are *Protorhus longifolia*, *Brachylaena uniflora*, *Canthium ventosum*, *Cassipourea gerrardii*, *Cryptocarya woodii*, *Rothmannia globosa*, *Anastrabe integerrima*, *Eugenia natalitia*, *Carissa bispinosa*, *Dracaena hookeriana* and *Popowia caffra*, and grow on the shallow sandy soils with minimum surface boulders. The climax forest was separated into two types, the first with *Drypetes gerrardii* and *Cola natalensis* on the very steep and rocky sites and the second with *Podocarpus latifolius*, *Bequaertiodendron natalense*, *Tabernaemontana ventricosa* and *Encephalartos villosus* on the less rocky and least steep sites. It is also possible that the latter type is the most mesic forest as it is south-facing.

Figure 4.

Distribution within the ordination of the density of three canopy species (*a* to *c*), six intermediate species (*d* to *i*) and three shrub species (*j* to *l*); (*a*) *Drypetes gerrardii* (1=1–4 and 2=7—10); (*b*) *Podocarpus latifolius* (1=1—3); (*c*) *Protorhus longifolius* (1=1—6 and 2=8—15); (*d*) *Drypetes gerrardii* (1=1—5 and 2=10—28); (*e*) *Anastrabe integerrima* (1=1—2=4—8); (*f*) *Cassipourea gerrardii* (1=1—7 and 2=20—38); (*g*) *Bequaertiodendron natalensis* (1=4—12, 2=17—36 and 3=48—85; (*h*) *Cola natalensis* (1=1—5 and 2=15—26); (*i*) *Tricalysia capensis* (1=1—5, 2=6—20, 3=21—60 and 4=>61); (*j*) *Dracaena hookeriana* (1=1—2, 2=8—18, 3=35—75 and 4=339); (*k*) *Encephalartos villosus* (1=5—10, 2=15—25, 3=30—70 and 4=70); and (*l*) *Popowia caffra* (1=1—8, 2=40—70).

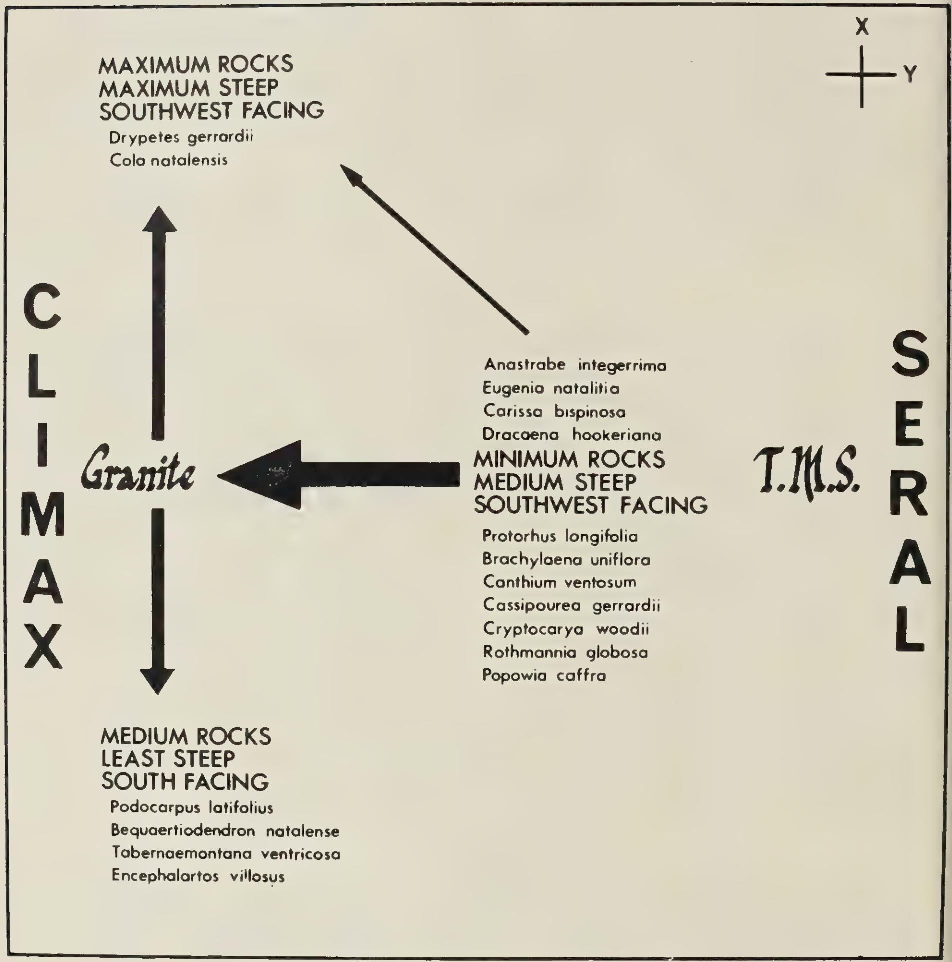

FIGURE 5.
A diagrammatic representation of suggested environmental gradients and successional trends within the ordination.

ACKNOWLEDGEMENTS

I wish to express my thanks to Mr. G. Webb and staff at the Natal University Computer Centre in Durban, the Natal Parks Game and Fish Preservation Board for permission to work in an area under their jurisdiction, and the Chief, Botanical Research Institute, and Secretary, Agriculture Technical Services, for permission to publish these findings.

REFERENCES

1. ACOCKS, J. P. H. (1953). Veld types of South Africa. *Mem. Bot. Surv. S. Afr.*, No. 28.
2. BRAY, J. R. & J. T. CURTIS (1957). An ordination of the upland forest communities of southern Wisconsin. *Ecol. Monogr.*, 27 : 325–349.
3. WOODS, D. B. & E. J. MOLL (1966). A quantitative ecological investigation of coast forest in Natal. (Unpublished.)